REMARKS

The Office Action dated May 30, 2007 has been received and carefully noted. The following remarks are submitted as a full and complete response thereto. Claims 1-15 are submitted for consideration

Claims 1, 4, 5 and 7 were rejected under 35 U.S.C. 102(b) as being anticipated by U.S. Patent No. 4,397,901 to Warren (hereinafter Warren) or U.S. Patent No. 5,098,871 to Ray (hereinafter Ray). The rejections are traversed as being based on references that neither teach nor suggest the novel combination of features clearly recited in claims 1, 4, 5 and 7.

Claim 1, upon which claims 2-7 depend, recites a ceramic matrix composite material which includes non-oxide dimensionally-stable ceramic fibers, which are formed in a complex fiber architecture by conventional textile processes. The matrix composite material also includes a thin mechanically weak interphase material, which is coated on the fibers and a non-oxide or oxide ceramic matrix, which is formed within the interstices of the interphase-coated fiber architecture. During a final step of composite fabrication or post treatment at a high temperature, the interphase is allowed to debond from the matrix while still adhering to the fibers, thereby providing enhanced oxidative durability and damage tolerance to the fibers and the composite material. Fiber debonding is induced after matrix consolidation via heat treatments of thermally induced stress states that act on the fiber interphase on cool down.

As will be discussed below, the cited prior art references of Warren and Ray fail to disclose or suggest the elements of any of the presently pending claims.

Warren discloses a method of making a composite article. The composite article is specifically adapted for use in high temperature, corrosive and erosive environments including a carbon fibrous substrate. The composite article includes a pyrolytic carbon sheath formed about each fiber of the substrate; a metallic carbide, oxide, or nitride compliant coating over the coated fibers of the substrate; and an impermeable metallic carbide, oxide or nitride outer protective layer formed about the entire periphery of the coated substrate. The compliant metallic coating is applied to the fibers in a manner such that any mechanical stresses built-up in the substrate due to a mismatch between the coefficient of thermal expansion of the fibrous substrate and the coating are effectively accommodated.

Ray discloses a method of forming an improved ceramic matrix composite wherein there is provided a slurry comprised of aluminum oxide, boron oxide and an organic binder suspended in a liquid, and combining the slurry with fibers. The aluminum oxide and boron oxide are capable of reacting to form aluminum borate. The improvement includes providing the fibers with a coating which forms a stable interface between the fibers and the aluminum borate.

Applicants submit that Warran or Ray does not teach or suggest each of the elements recited in the pending claims. Claim 1 recites, in part, fiber debonding is induced after matrix consolidation via heat treatments of thermally induced stress states

that act on the fiber interphase on cool down. Warren does not teach or suggest this feature.

Warren discloses that first a multiplicity of carbon fibers are assembled into a basis or starting substrate. Then, according to Warren, the starting substrate is placed in a controlled environment, heated to between 1500°F and 4200°F and exposed to a carbonaceous gas, as a uniform layer of CVD carbon is deposited about each of the fibers of the substrate. Warren also discloses that an interim substrate is formed, shaped, placed in a second controlled environment, heated to between 1800°F and 3200°F and reacted with a siliceous material for a period of time sufficient to permit the silicon to react with the CVD carbon. Then, according to Warren, the article is again heated and exposed to a gas containing carbon and silicon to form a uniform CVD seal coating about the entire periphery of the article. See Col. 6, line 58 – Col. 7, line 12 of Warren. Warren does not teach or suggest that fiber-debonding is induced **after** matrix consolidation via heat treatment or thermally induced stress-states that act on the fiber interphase/matrix interface on cool down, as recited in the pending claims.

The Office Action acknowledged that Ray does not teach fiber debonding after matrix consolidation but alleged that Ray teaches an equivalent product. Applicants submit that under 35 U.S.C. 102, a cited reference must teach each reference of the pending claims. As noted in the Office Action, Ray does not teach fiber debonding after matrix consolidation. Therefore, Ray does not teach or suggest each element of the pending claims. Based on the distinctions noted above, Applicants respectfully assert

that the rejections under 35 U.S.C. §102(b) should be withdrawn because neither Warren nor Ray teaches or suggests each feature of claim 1 and hence, dependent claims 2-6 and 9-15 thereon.

Claims 1, 4 and 5 were rejected under 35 U.S.C. 103(a) as being anticipated by U.S. Patent No. 5,476,685 to Rocher in view of U.S. Patent No. 6,506,483 to Fehrenbacher. Claims 8, 9 and 11-15 were rejected under 35 U.S.C. 103(a) as being unpatentable over Rocher in view of Fehrenbacher. According to the Office Action, Rocher teaches or suggests all of the elements of claims 1, 4, 5, 8, 9 and 11-15 except for teaching that its fibers are stable. Therefore, the Office Action combined Rocher and Fehrenbacher to yield all of the elements of claims 1, 4, 5, 8, 9 and 11-15. The rejections are traversed as being based on references that neither teach nor suggest the novel combination of features clearly recited in independent claims 1 and 8.

Claim 8, upon which claims 9-15 depend, recites a method of forming a ceramic matrix composite including selecting chemical compositions for non-oxide fibers, a thin and mechanically weak interphase material, and a non-oxide or oxide matrix. The method also includes forming the non-oxide dimensionally-stable fibers into complex architectures and depositing the thin and mechanically weak interphase material on the non-oxide fibers. The method further includes depositing the non-oxide or oxide matrix on the interphase material and processing the non-oxide fibers, the interphase material, and the non-oxide or oxide matrix such that, after a final composite processing, debonding or mechanical decoupling is already achieved between the interphase material

and the non-oxide or oxide matrix. Fiber debonding is induced after matrix consolidation via heat treatments of thermally induced stress states that act on the fiber interphase on cool down.

As will be discussed below, the cited prior art references of Rocher and Fehrenbacher fail to disclose or suggest the elements of any of the presently pending claims.

Rocher discloses that carbon fibers are used to form reinforcement textures in thermo-structural ceramic matrix composite materials. The materials have properties that make them particularly apt to withstand large mechanical stresses at high temperatures. They are composed of a ceramic matrix deposited within the porous structure of a fibrous reinforcement. Specifically, the fibrous reinforcement made of carbon is used to construct a pre-form of a work piece to be manufactured. The fibrous reinforcement is then densified by the matrix material. This densification can be achieved by liquid phase impregnation using a matrix precursor, followed by a thermal treatment leaving behind a deposit of matrix materials on the fibers within the reinforcement. Several impregnation cycles are generally necessary to obtain the required degree of densification. Densification can also be obtained by chemical vapor infiltration inside an infiltration furnace. See Col. 1, lines 19-41.

Rocher also teaches that the aim of the invention is achieved by submitting the carbon fiber reinforcement material, prior to densification by the matrix, to a thermal treatment in a non-oxidizing environment at a temperature greater than 1300° C. and less

than 2200° C. Such a thermal treatment makes it possible to obtain a composite material having improved mechanical strength, in particular better tensile and creep strength. The mechanical strength of the composite material is improved by performing a heat treatment of the carbon fiber reinforcement in a non-oxidizing environment. The heat treatment is carried out on the carbon fiber reinforcement either before or after making the fibrous reinforcement perform, but always before deposition of the ceramic matrix material. Col. 1, line 59-Col. 2, line 14.

Fehrenbacher discloses that fiber reinforced ceramic matrix composites depend on a fiber/matrix interface coating that is capable of transmitting load from the matrix to the fibers as well as deflecting or blunting matrix cracks. The crack deflection capabilities are attributed to the interfacial slip or debonding of the interfacial coating from the fiber. The strength of the fiber debond coating to the fiber must be strong enough to transmit the matrix load but weak enough to debond from the fiber once cracks begin to propagate to the interface coating. Debond coatings must adhere to the underlying reinforcing fiber with enough strength to permit the fiber to provide is reinforcing function, while being able to "debond" from the fiber and allow relative movement between the fiber and the coating during a stress event. Col. 1, lines 1-40.

Applicants submit that the combination of Rocher and Fehrenbacher simply does not teach or suggest each of the elements recited in the pending claims. Claims 1 and 8 recite, in part, fiber debonding is induced after matrix consolidation via heat treatments of thermally induced stress states that act on the fiber interphase on cool down. Rocher

describes heat treatments to carbon fibers pre-forms and in one case heat treatment of interface-coated fiber pre-forms. In Rocher, the heat treatments do possibly shrink the fibers resulting in fiber-stabilization and they may alter the fiber surface to promote weak interfaces between the fibers and the matrix. According to Rocher, all of the above is performed **prior** to the deposition of the matrix. In the present invention, on the other hand, fiber-debonding is induced **after** matrix consolidation via heat treatment or thermally induced stress-states that act on the fiber interphase/matrix interface on cool down.

In the present invention, as recited in the pending claims, the ceramic matrix composite material includes non-oxide dimensionally-stable ceramic fibers. Thus, there is no alteration to the fibers as the present invention requires already stable fibers. The present invention, as recited in claims 1 and 8, recites a method of final fabrication or post treatment at sufficiently high temperatures of a non-oxide matrix composite system reinforced by micro-structurally and dimensionally stable non-oxide fibers in order to in-situ shrink a dimensionally unstable fiber coating onto the fiber and away from the matrix. The present invention, as recited in claims 1 and 8, also recites a method of pre-selecting the constituents of a non-oxide or oxide matrix composite system reinforced by micro-structurally and dimensionally stable non-oxide fibers in order to develop tensile residual stresses between fiber coating and matrix during cool down from the final matrix fabrication temperature. Therefore, Applicants respectfully asserts that the rejection under 35 U.S.C. §103(a) should be withdrawn because neither Rocher nor Fehrenbacher,

whether taken singly or combined teaches or suggests each feature of claims 1 and 8 and hence, dependent claims 4, 5, 9 and 11-15 thereon.

Claim 10 was rejected under 35 U.S.C. 103(a) as being unpatentable over Rocher in view of U.S. Patent No. 5,945,166 to Singh and Fehrenbacher. According to the Office Action, Rocher and Fehrenbacher teaches all of the elements of claim 10 except for teaching such treatment to manipulate stress in the matrix and further shrink the product. Thus, the Office Action combined the teachings of Rocher, Fehrenbacher and Singh to yield all of the elements of claim 10. The rejection is traversed as being based on references that neither teach nor suggest the novel combination of features clearly recited in independent claim 8, upon which claim 10 depend.

Singh discloses manipulation of residual stress states in order to fabricate "zones" or layers of compressive/tensile residual stress states to accommodate tensile/compressive thermally induced stresses during the service of a part. These are macro stresses formed in the outer surfaces of the composite itself.

Singh does not cure any of the deficiencies of Rocher and Fehrenbacher with respect to claim 8, as described above. Specifically, Singh does not teach or suggest wherein fiber debonding is induced after matrix consolidation via heat treatments of thermally induced stress states that act on the fiber interphase on cool down, as recited in claim 8. Therefore, Applicant respectfully asserts that the rejection under 35 U.S.C. §103(a) should be withdrawn because neither Rocher, Fehrenbacher nor Singh, whether

taken singly or combined, teaches or suggests each feature of claim 8 and hence, dependent claim 10 thereon.

As noted previously, claims 1-15 recite subject matter which is neither disclosed nor suggested in the prior art references cited in the Office Action. It is therefore respectfully requested that all of claims 1-15 be allowed and this application passed to issue.

If for any reason the Examiner determines that the application is not now in condition for allowance, it is respectfully requested that the Examiner contact, by telephone, the applicants' undersigned attorney at the indicated telephone number to arrange for an interview to expedite the disposition of this application.

In the event this paper is not being timely filed, the applicants respectfully petition for an appropriate extension of time. Any fees for such an extension together with any additional fees may be charged to Counsel's Deposit Account 50-2222.

Respectfully submitted,

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Enclosures: Petition for Extension of Time
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